A Petrographic Study of Lava and Ash from the Volcano Xitle, central Mexico

Senior Thesis

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Requirements for the Degree Bachelor of Science

by

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Contents

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Introduction

The volcanic terrain of Mexico is divided into two provinces. The Rio Lerma Province overlies the much larger Cordilleran Province. The Rio Lerma Province extends across Central Mexico (fig. 1) between the Pacific and Gulf of Mexico coasts. The area is dominated by strato-volcanoes and these are accompanied by the normal scoria cones, lava domes, and laharic deposits. The oldest volcanics are of Early Miocene age with volanic activity continuing to the present day.

The rocks analyzed in this paper were collected in the Rio Lerma province. They are interpreted as being erupted from Xitle volcano which is a small Quaternary scoria cone approximately 2.5km northeast of the much larger Ajusco volcano (fig 2). The precise location of Xitle is $19^\circ 15'$ North and $99^\circ 13'$ West. It is 3,128 meters above sea level or about 100 meters above the surrounding lava field.

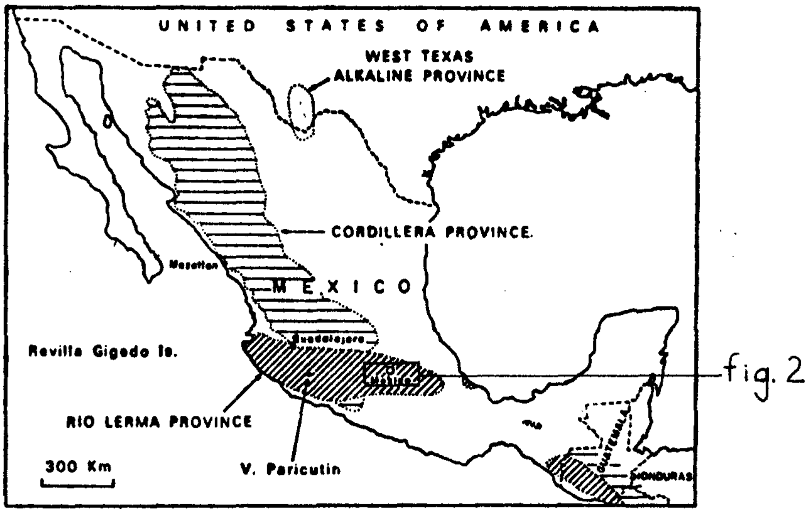


FIG. 1 - Map of the Volcanic Provinces of Mexico.

fig.3

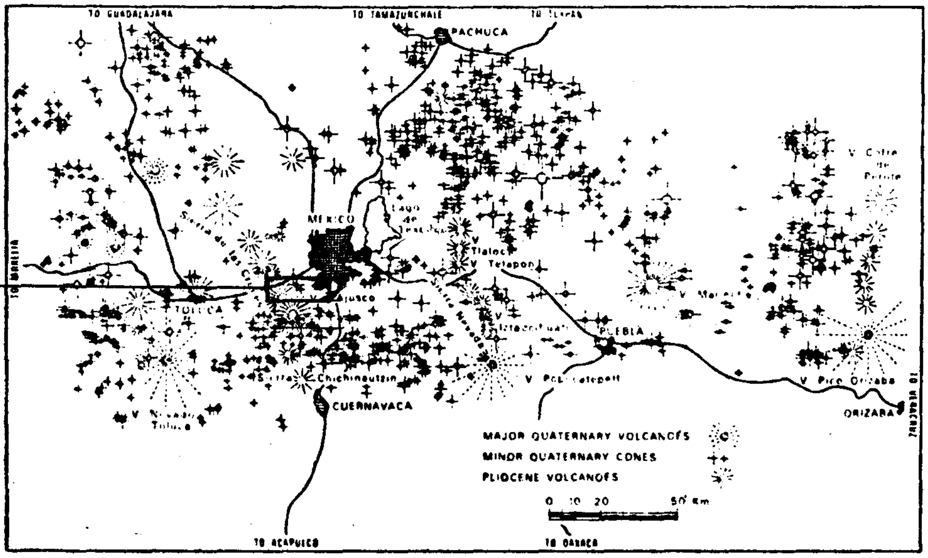


FIG. 2 - Map of Volcanoes in the Mexico City Region,

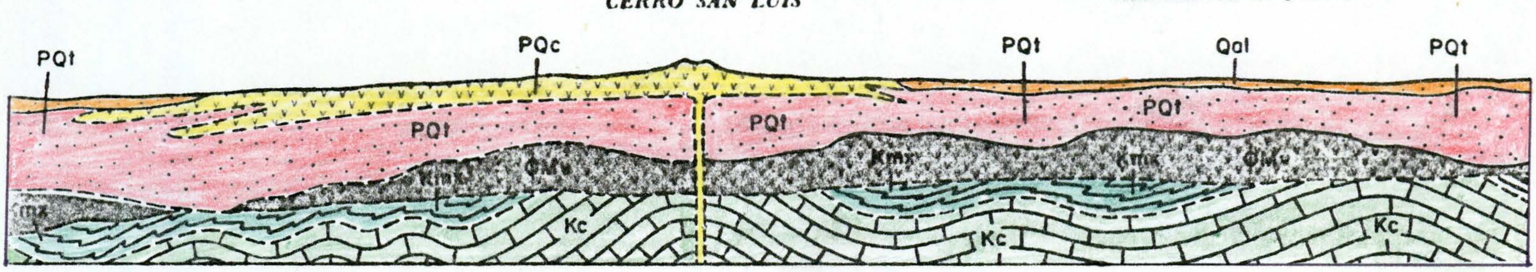
Local Geology and Structure

The entire Rio Lerma province is interpreted as a graben. The main faults trend invariably east-west. The area is thought to be a continental extension of the Clarion fracture zone, a transform fault intersecting the Mid- Pacific Rise (Bullard, 1969) or fault slices (Mooser and Maldonado-Koerdell,, 1961) of the San Andreas fault.

The volcanoes of central Mexico are probably not a result of subduction. The north-south trending mountains such as the Sierra Nevada are parallel to the Pacific trenches and most likely represent volcanic activity resulting from subduction of the Pacific plate. Unlike these, the volcanoes of central Mexico are thought to be a result of rifting as would be expected in graben structure.

Locally, Xitle volcano is underlain by faulted and folded Cretaceous rocks. (fig.3) This formation is overlain by the Eocene Balsas Formation. The Balsas is sedimentary also but contains volcanic breccia. Above this are Oligocene volcanic rocks, mainly clastics and lahars. The surface area around Xitle is all basaltic or rhyodacitic lava and volcanoclastics of Pliocene and younger ages.

GEOLOGIC MAP OF XITLE AREA



General Cross section

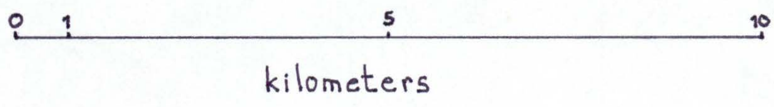


fig. 3

Petrography

Three types of volcanic rocks were analyzed. A vesicular basalt, which overlies the scoria and ash analyzed, was examined most extensively. The underlying volcanics, however, were also studied.

The vesicular basalt appears in hand specimen as a melanocratic, aphanitic rock with elongate vesicles of about 1cm in length. Olivine is recognizable in the hand specimen as phenocrysts of about 2-2.5mm. In thin section it is seen as a pilotaxitic olivine basalt. Olivine is present as about 10% of the rock as phenocrysts 2mm and smaller. Plagioclase is seen as microlites and very few phenocrysts (.5mm) and composes about 60% of the rock. Glass is very prominent and is a dark iron rich variety and makes up about 20% of the rock. Magnetite is present (5%) as euhedral crystals in the olivine. Crystallites of magnetite make up the remaining 5%. (fig. 4)

The scoria, also melanocratic, appears to be of basic origin in hand specimen. No minerals are identifiable megascopically. In thin section the scoria contains olivine as phenocrysts. Pilotaxitic texture is seen in small areas and the plagioclase is slightly larger than the basaltic plagioclase. Glass is present and is dark brown to opaque. Magnetite and crystallites make up the remainder of the rock. The percentages of each mineral are about the same as in the basalt. (fig. 5)

The ash is similar mineralogically. Again the plagioclase is slightly larger than the basaltic variety. A very few crystalites are present in the glass. Olivine is present in the same percentage as 1mm phenocrysts.

See diagrams on following pages for detailed petrographic descriptions and composition analysis.

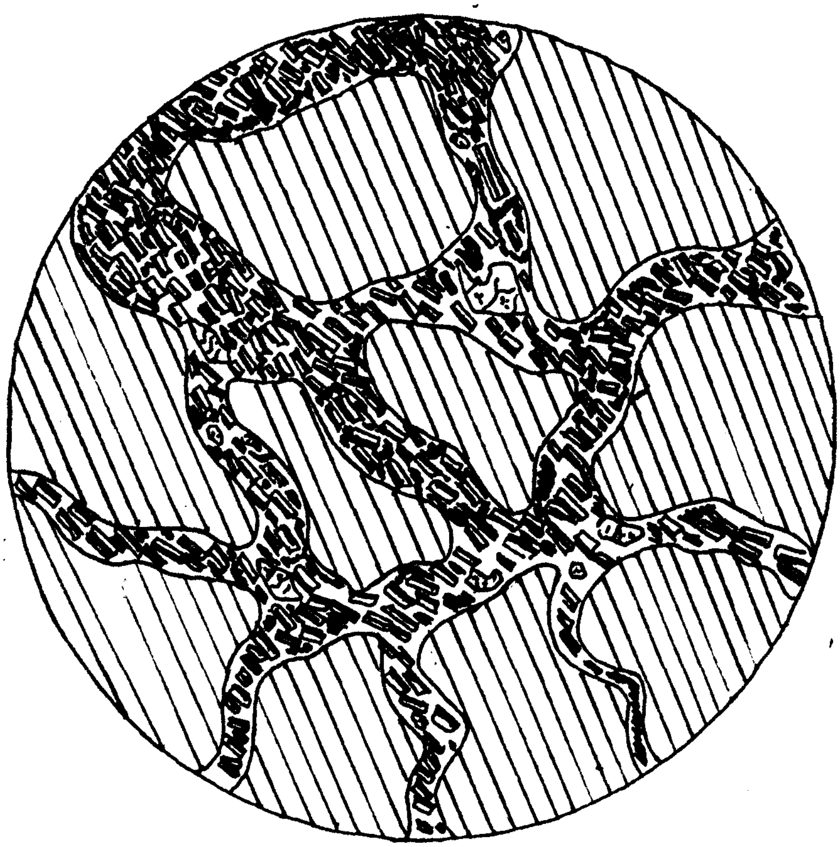
BASALT XL—4

X40

1 MM

fig. 4

SCORIA XS-4

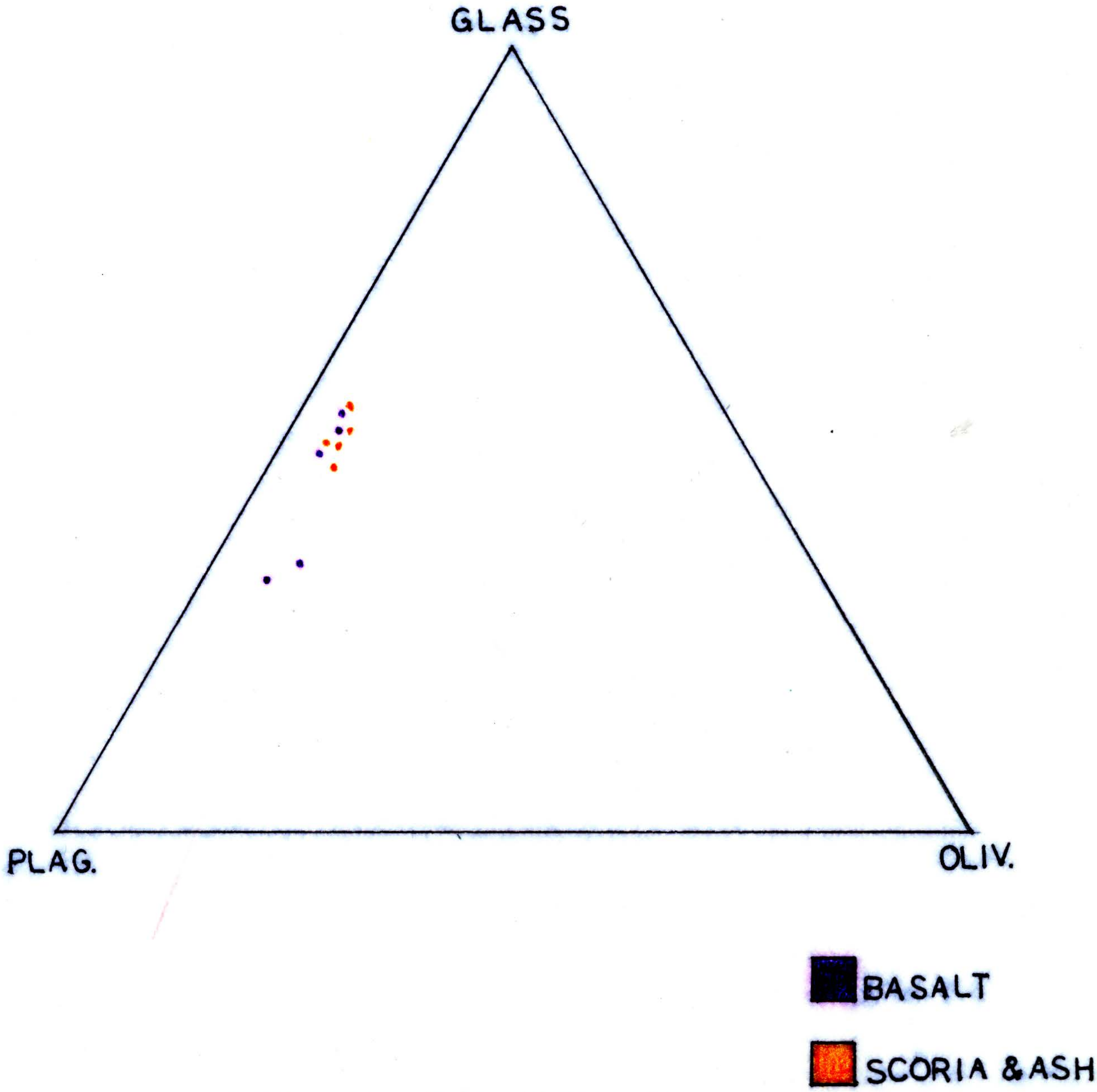


X40

explanation
olivine
plagioclase
glass
vesicle

1 MM

fig. 5



BASALT COMPOSITION

fig. 6

Mineralogy

Plagioclase

The plagioclase in the rocks studied is nearly all microlitic. There are a few (5% of total) phenocrysts. Most of the plagioclase is aligned in the direction of flow (pilotaxitic). The feldspar was analyzed by the Michel-Levy method and microlite method of Moorhouse. The plagioclase was found to be An_{48}-An_{54}. This sodic laboradorite was invariably twinned by the albite, pericline, and Carlsbad laws. The microlites are up to .25mm long and the phenocrysts are up to 1mm long. Zoning is present in phenocrysts and there are also a few grains with zones of inclusions suggesting reaction with the magma.(fig.7,8)

Olivine

The olivine is invariably an iron rich variety, showing a negative optic sign. Phenocrysts are beautifully doubly terminated and unaltered. Most crystals are skeletal or contain embayments which would be indicative of quick cooling. Two and a half millimeters is the ultimate length and some are extremely small (microlites). All phenocrysts contain varying amounts of euhedral magnetite, and brown chrome spinel(?).

Glass

Nearly all the glass, which is plentiful, is very dark brown suggesting an excess of iron. Indices are of refraction are normal for a basic rock. (fig.9)

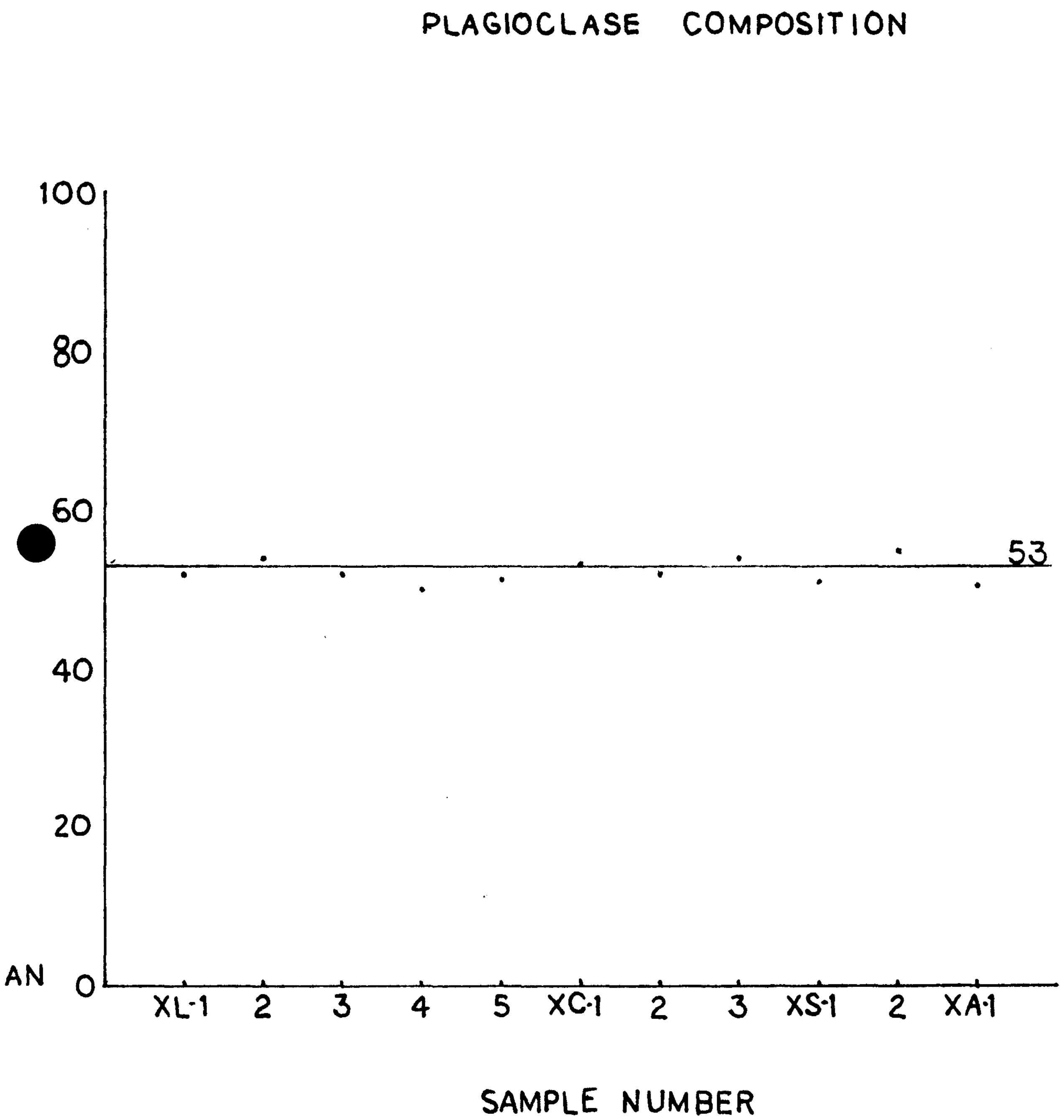

PLAGIOCLASE COMPOSITION
100
80
60
40
20
AN 0
53
XL-1
2
3
4
5
XC-1
2
3
XS-1
2
XA-1
SAMPLE NUMBER

fig. 7

REFRACTIVE INDICES
PLAGIOCLASE

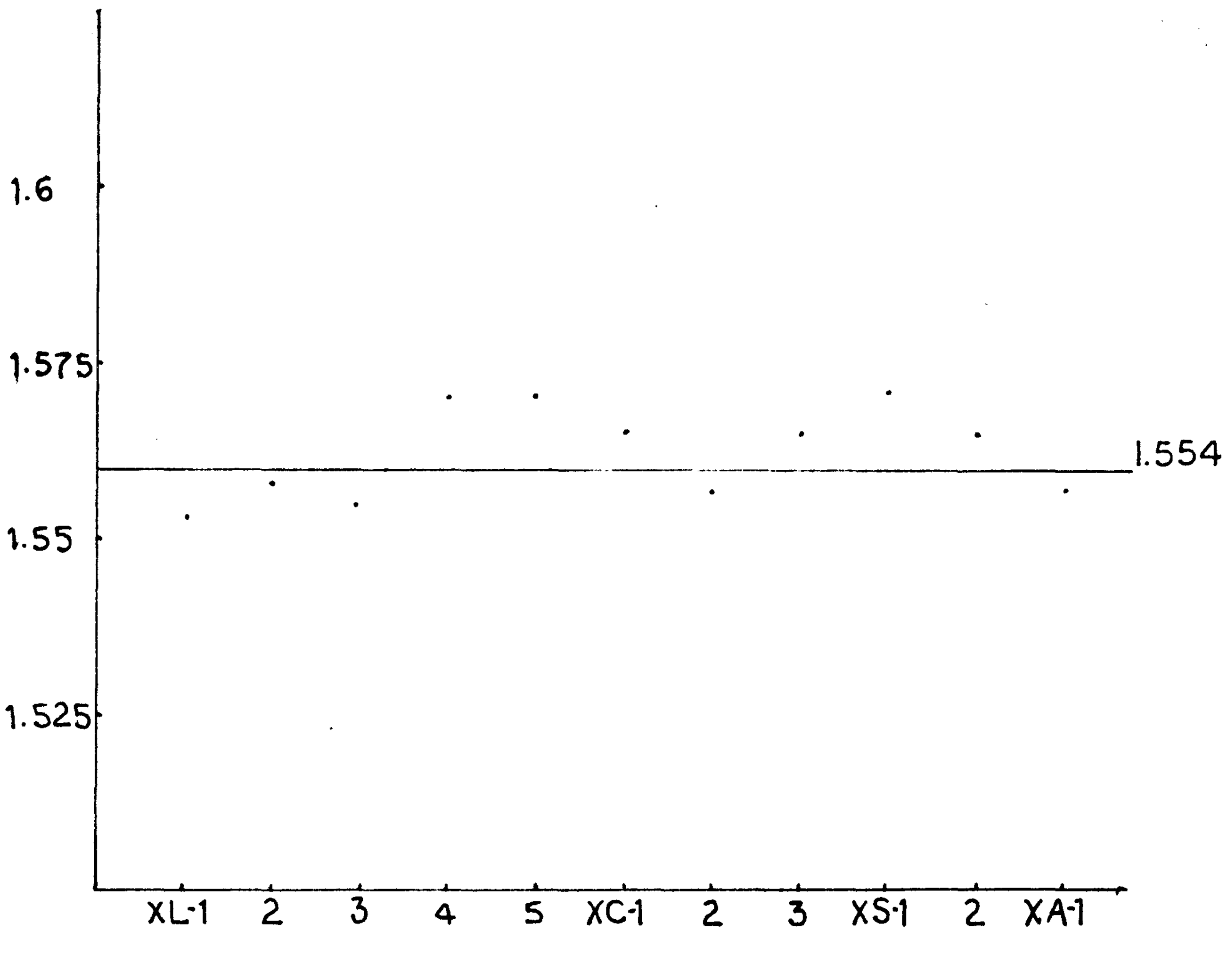


fig. 8

REFRACTIVE INDICES
GLASS

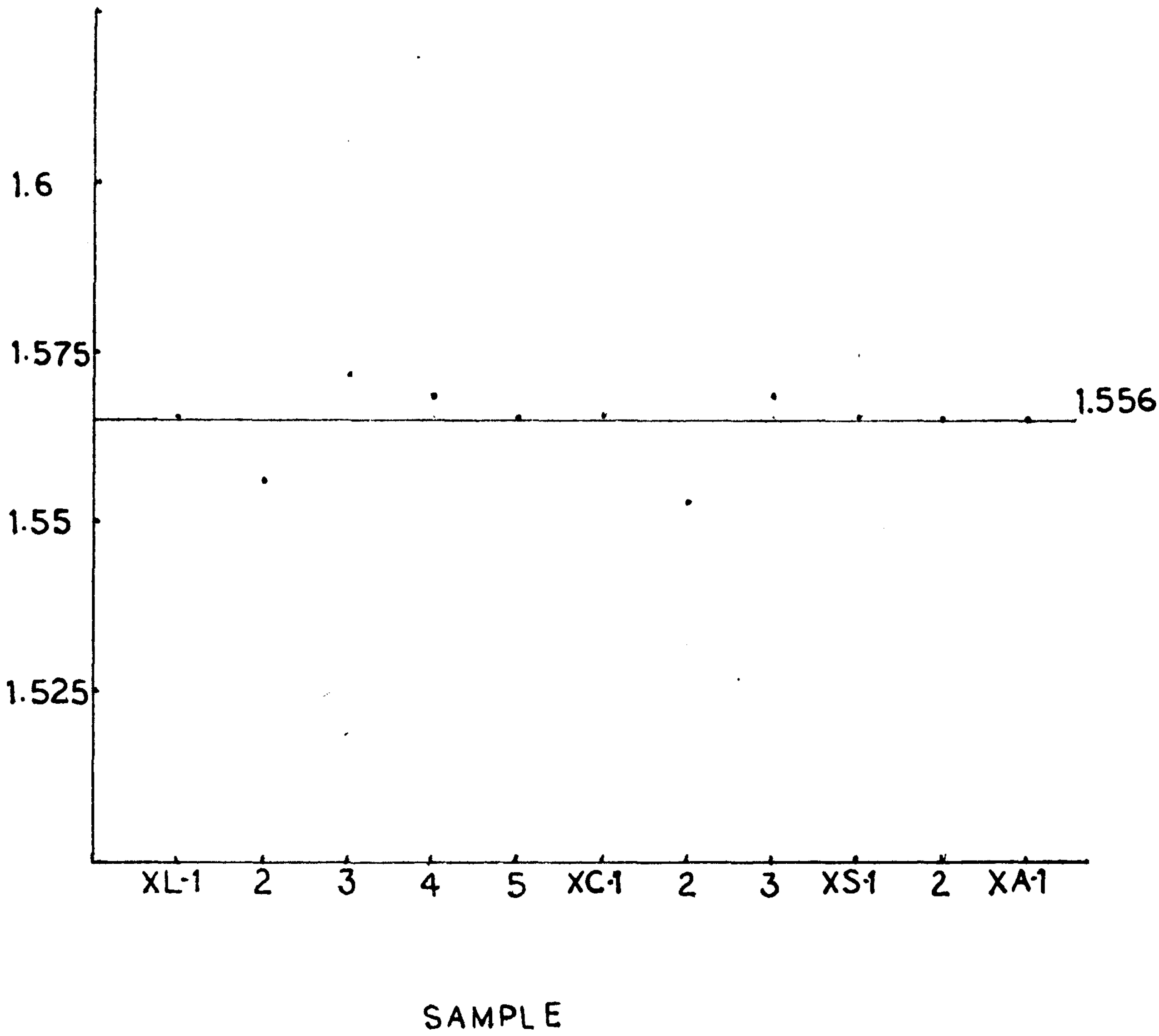


fig. 9

Lab Analysis Techniques

Thin sections were prepared by the author. Each basalt sample was cut in at least two different diredtions offering maximum variability in texture. Scoria and ash samples were impregnated with epoxy and then cut in a fashion similar to the basalts. In addition grain mounts were prepared for extremely fine ash particles. Indices of refraction were determined using standard Cargille oils,and point counts were compiled with the aid of a mechanical sta ge. All microscope work was done with the Nikon Labophot-Pol.

Petrogenesis

The magma from which these rocks were derived was probably formed by melting processes in the upper mantle. Peridotite in the mantle is partially melted to yield a liquid of basaltic composition. In this case it is a olivine tholeiite magma. This magma is separated by a "thermal divide" from the alkali series. This magma was derived from a source probably at more than 100km below the surface. This conclusion is based on the experimental evidence that pyroxenes decrease in abundance with increasing pressure (depth). (fig.10)

Because of the large percentage of glass present these rocks were obviously quickly quenched upon reaching the surface of the earth. The presence of such a large amount of glass could mean a quick ascent to the earth's surface, which would be possible due to the nature of the faulted basement rocks of the area. This would allow for little fractionation and little crystal settling which again seems to be the case. Olivine being the most dense mineral present is very prevalent in all samples.

The strongest evidence of an olivine tholeiite is from experimental work done by Green and Ringwood. In an olivine tholeiite, olivine will begin crystallization at about 1340° C and then plagioclase at 1260° C. Clinopyroxene does not show up until the magma reaches 1200° C. Most other combinations such as olivine basalt and alkali basalt show the crystallization of clinopyroxene before plagioclase. This obviously has not happened here because there is no identifiable pyroxene present.

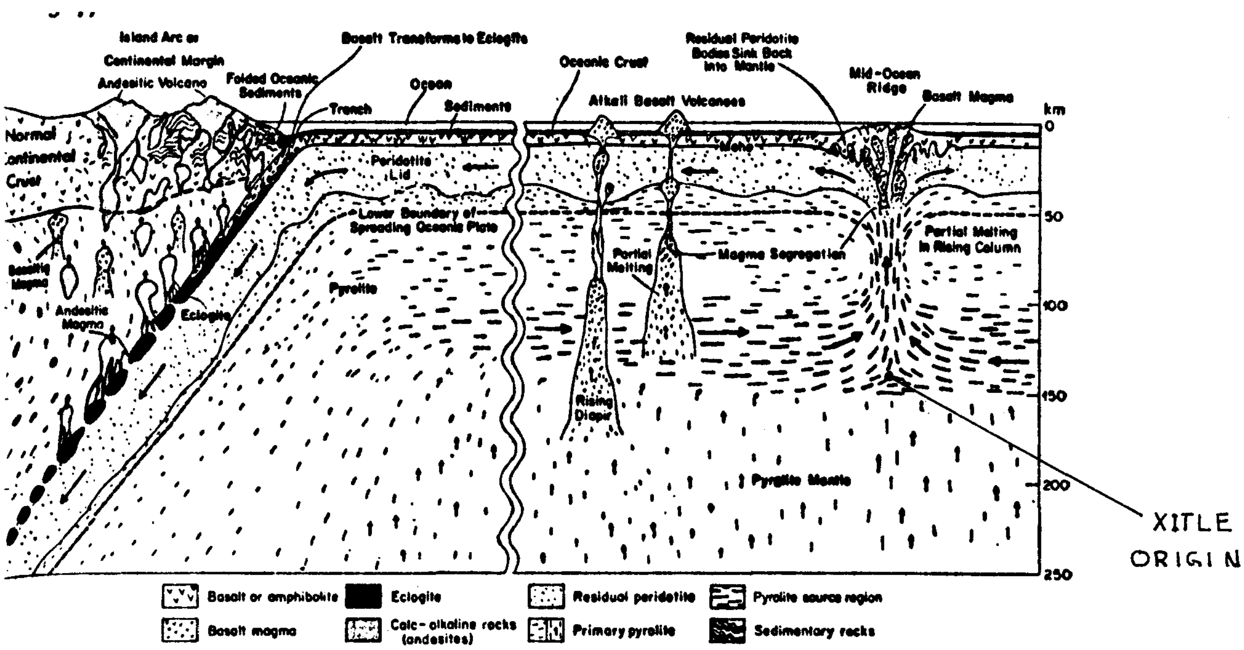


FIG. 11. Model of irreversible mantle differentiation and continental evolution (From Ringwood 1969 with the permission of the American Geophysical Union).

fig. 10

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